FOOD ENVIRONMENTAL FOOTPRINT: A BOTTOM-TOP APPROACH TO REDUCE IT

Eleonora Farcomeni
Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft

ABSTRACT

The way we produce and consume food poses big challenges for the years to come. While the population is growing, agriculture is one of the human endeavors having a major impact on the environment, underlining the urgency of rethinking our food strategy. Nowadays agriculture is responsible for a quarter of greenhouse gas emissions globally and it demands 70% of the global freshwater. Finally, In order to ensure the required annual quantity of food, a lot of the global Gha is devoted to food production. Those 3 elements - CO2, virtual water, and land accounting - are together shaping the environmental footprint of the food system, also called foodprint. How can we reduce the impact on the food system in terms of natural resource usage? Which scenario could we build shifting our eating habits? Can we invest in cities and citizens with projects involving more the city dwellers in food-related practices? Rethinking our food strategy within cities starting from its inhabitants, following a bottom-top approach, can help realize the vision of a more sustainable consumption and generate significant environmental, economic, and health benefits within and beyond their boundaries. In this paper, a case study in Amsterdam - the Brettenzone - will be selected to showcase how bringing food practices back to urban environments can raise awareness about food impact both our life and on the surroundings, creating healthy, green, livable, and sustainable cities.

KEYWORDS: *Food system, environmental footprint, FEW, FEW-print, food-energy-water, local food systems, diet, sustainable consumption.*

I. INTRODUCTION

1.1. Contextual Framework: Farming and the beginning of Anthropocene

The geological time scale is a system used by the scientific community to divide the time spent on earth. Each period since the birth of the Earth is described in precise geochronological units: eons (milliard of years), eras (hundreds of millions of years), periods (decades of millions of years), epochs (millions of years), and ages (thousands of years). It is a sort of home address; to be clear today we live into the Phanerozoic eon, Cenozoic era, Neogene period, Holocene epoch. Some of the transitions within the chronological line are determined by big events such as extinction - like the extinction of the dinosaurs - while other borders are more subtle (Mancuso, 2018). Although in the last 11.700 years, after the last glaciation, Earth is in the Holocene epoch, the majority of the scientific community believes man has already changed the planet's environmental system irreversibly and that consequentially the new epoch should be called Anthropocene. Experts are currently looking for the precise starting point of this new epoch: some are pointing at the industrial revolution whereas others think technology is the cause, however most scientists search for the start of this transition in earlier times with the beginning of farming.

The term Anthropocene (from Anthropos, man) was originally coined by the American biologist Eugene Stormer but is famous thanks to the Dutch Paul Crutzen, who won a Nobel prize in chemistry. Crutzen affirmed that the ongoing geological epoch is characterized by the quick alterations created by human activities, which are modifying the whole environment, from the soils to the climate (Crutzen, 2006). As a matter of fact, the beginning of human alterations to the Earth environment can be traced back to the beginning of farming - which compelled our nomadic ancestors to settle. Man was at that point starting to modify the natural environment to fulfill his basic necessities, altering a system which had been stable for millions of years. Together with human evolution, also agriculture evolved rapidly, and its consequences are now pointing out the necessity of rethink our food system in order to address the climate global challenges we will have to face in the coming decades.

1.2. Problem Statement: the necessity of rethinking our food strategy

With the world population increasing, the number of agricultural practices and lands devoted to crop-related practices are expanding, but also changing at incredible speed. As a result, the idyllic vistas of the rural landscapes have disappeared and were replaced by infinite planes of high-tech greenhouses. The intensive production of food, necessary to feed a growing population following unsuitable diets (EAT-Lancet Commission, 2019), unfortunately results in monoculture and deforestation.

Hence, the central problem this paper will address is the necessity to rethinking our food strategy, especially as the population is growing and the current linear food system will in the future be unable to feed everyone without using all the natural resources.

1.3. Background the problem

1.3.1. Population growth and the role of cities

The population is growing globally. In the coming decades, feeding people is going to become one of the biggest challenges of our society. The latest United Nations reports estimated that the global population is expected to increase by 3 million in the next 30 years, reaching 9.7 billion people in 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2015). This means that we will have extra people to feed, a task completely impossible if we stick to the current linear food system. The biggest question in front of this growth pattern of population is: how are we going to feed them?

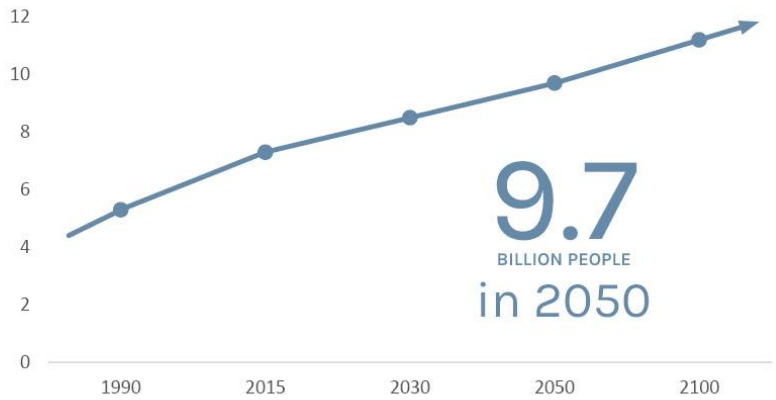

Figure 1. Global population. (United Nations, Department of Economic and Social Affairs, Population Division, 2015).

Given for proved global population is increasing, it is actually growing especially within cities. In 2009, for the first time the amount of people living in cities overpassed the rural population, and its number is expected to grow to 68% by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2018). Moreover, cities are the main responsible in terms of emissions and use of resources: they consume 75% of the global natural resources and 80% of the global energy supply (UNEP-DTIE, 2013). Finally, cities as the main place where food is consumed: it is estimated that they will consume 80% of food in 2050 (Ellen MacArthur Foundation, 2019), showing the pivotal role they can play in a food transition.

1.3.2. Downsides of the current food system

Our current food system is constituted by a sequence of linear steps which are becoming unsustainable. The evidence of the problem is underlined by several factors that present the impact of agriculture-related activities: the first factor proving the necessity of rethink our food strategy, is its overall carbon emission. Agriculture is responsible for a quarter of greenhouse gas emissions globally, making the agri-food industry is the global second-largest emitter of greenhouse gases (Ellen MacArthur Foundation, 2019). In terms of overall emissions, these activities are second only to the ones related to the building environment, underlining the responsibility that designers, architects and space planners have nowadays relating to find new solutions to safeguard the planet and its resources. Secondly, this sector has a huge environmental footprint: it is estimated that approximately 70% of global freshwater demand is used for agriculture (Water Civilization International Centre, 2018) and its use of land is currently degrading the natural reserves in terms of biodiversity. The current world relies on just three crops for more than 50% of its plant-derived proteins (Biodiversity International, 2017) contributing to a dramatic loss of biodiversity (over 60% in the last 40 years) (Grooten & Almond, 2018). Finally, the cost of this system has to be considered. Overall, for every dollar spent on food, society pays two dollars in health, environmental, and economic costs. Half these costs - totaling USD 5.7 trillion each year globally are due to the way food is produced (Ellen MacArthur Foundation, 2019).

1.4. Research Question

This paper aims to investigate the environmental footprint of food in general and zooms in on landuse, water and energy for the Brettenzone area and surroundings in Amsterdam, the Netherlands while also addressing strategies to reduce emissions, virtual water use and land accounting, proposing shifts in the current diet and the introduction of local food systems within cities.

Related sub-questions, are:

What is the carbon footprint of food?
What is the virtual water of food?
What is the embodied land of food?
How can we calculate the environmental footprint of a community related to its food consumption?
How can we reduce the environmental footprint of food?
Which future scenarios can we build?

Rethinking our food strategy within cities can help realize the vision of a more sustainable consumption and generate significant environmental, economic, and health benefits within and beyond their boundaries.

II. BACKGROUND AND TOOLS

2.1. System boundaries: the Brettenzone

Within a wider food and agriculture systems, localized urban food hubs can play an essential role (Norman, 2012). Therefore, farming activities should be (re)introduced to urban contexts, especially as the experience within the city of such activities can help to urge people to rethink their impact on environment and start the process towards a circular economy for food, which is local and in which waste is reused.

In this paper, the case study selected for this challenge is the Brettenzone, a green area in the northwestern part of Amsterdam that connects the city center with the countryside towards Halfweg. The area has been selected because of both its history and its current opportunities. Known as the *last wild area within Amsterdam*, this 9-kilometer by 500-meter strip of land has been demanded for agriculture since the 11th century. Nowadays it performs as a collection of unfinished experiment of bringing back farming and nature to the city, enriched by an incredible local flora and fauna. From the municipality (Municipality of Amsterdam, City area New-West, 2012), several projects and proposals are focusing on its development, showing the potential of this area and the ole it can play within the city.

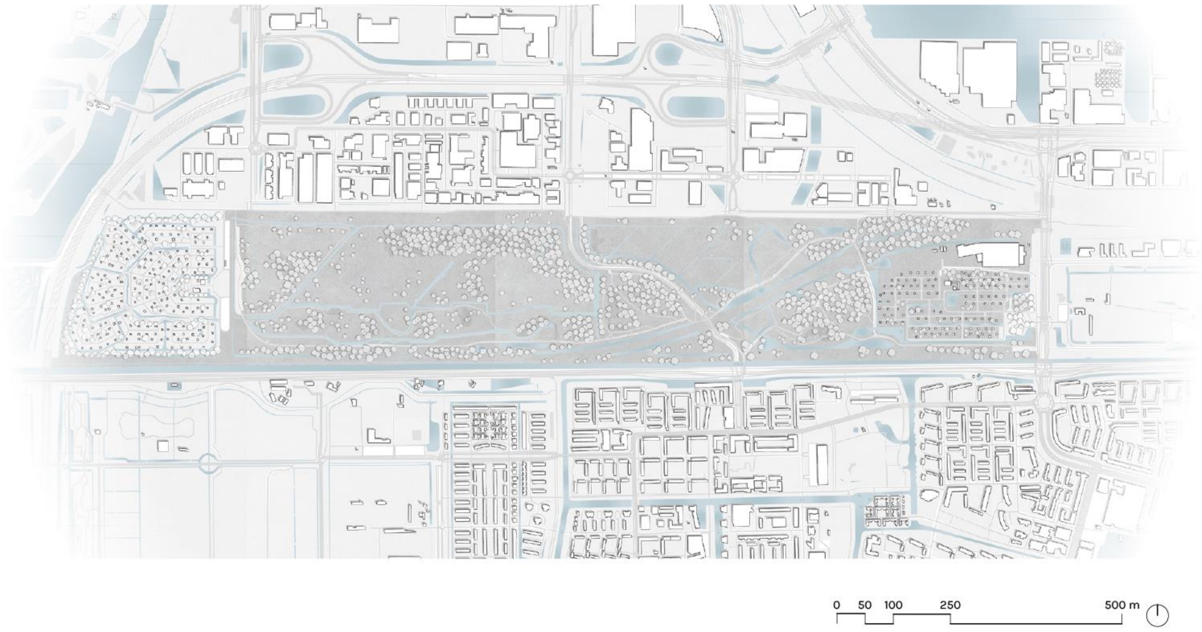

Figure 2. The Brettenzone, Amsterdam. Image by the Author

2.2. FEWprint tool

Food, energy and water (FEW) are three essential resources for human society (Karabulut et al., 2014) (Andrews-Speed et al. 2019) but are faced with growth in demand and limited supply, especially due to our food habits. In this research, the FEWprint tool ~~(Caat et al., 2020) –~~ a Food, Energy & Water consumption calculator - (Caat, et al., 2020) ~~-designed by Nick ten Caat within Delft University of Technology, dept. of AE+T, Chair of Climate Design & Sustainability –~~will be adopted as the main methodology in order to calculate aspects of the environmental footprint of food.

The use of this tool has four functions:

(1) Calculate the FEWprint of the status-quo of a community/neighborhood

(2) Explore alternative sustainable sources and assess its impact on the FEWprint

(3) Assess the impact of dietary changes on the FEWprint

(4) Explore the resource and carbon implications of Urban Farming (UF) on the FEWprint of a community

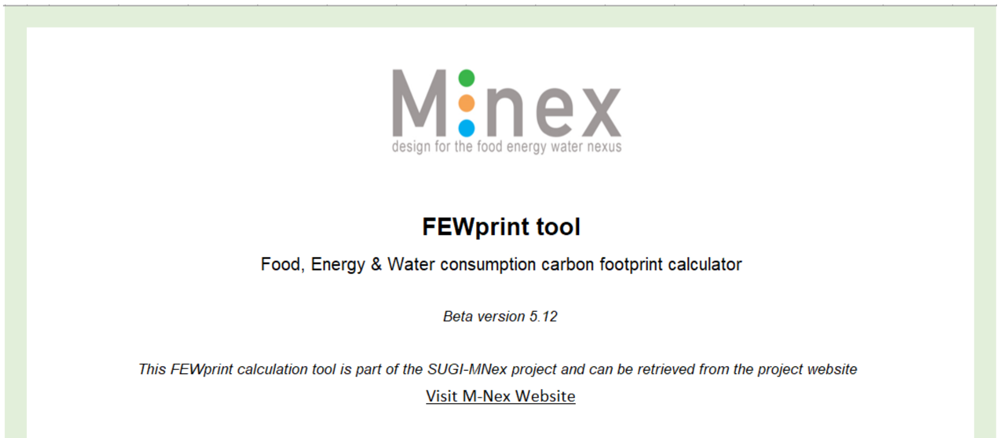

Figure 3. FEWprint tool. *Caat, N. ten, Tenpierik, M. J., Tillie, N. M. J. D., Dobbelsteen, A. van den, Sanyal, T., Cullen, S., … Monti, S. (2021). Urban FEW nexus - Carbon emission assessment of urban communities by using the FEWprint tool. Preliminary Paper.*

This methodology will provide a cross-sectoral view on the issue. By using the Nexus approach the complex and dynamic interrelationships between water, energy and food, can be better comprehended and provide insights into a better management of our limited resources. It forces to consider that the effects of a decision could verse on different fields, envisioning potential compromises and collaboration. This approach allows to give input into the design process and evaluate its outcome.

III. METHODS

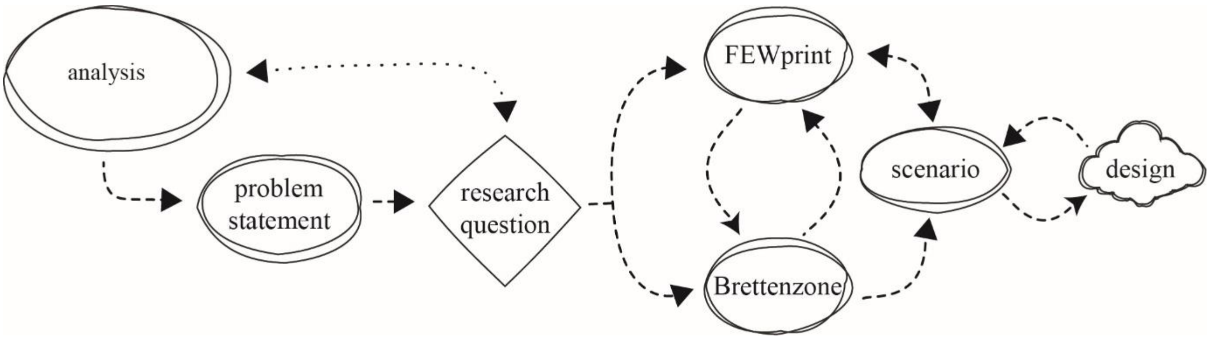

Figure 4. Methodology flowchart.

This paper focuses on the endpoints of food systems: sustainable consumption and sustainable production. Although most of the food production takes place within the peri-urban area (Ellen MacArthur Foundation, 2019), starting from local communities and raising awareness of the need to reform of our nutritional habits. The research strives to build a bottom-top strategy to face a food transition, starting from analyzing the current food consumption and its environmental repercussion, addressing possible changes and finally suggesting development principles based on local management toward a circular economy for food.

The research starts from a comprehensive analysis and literature review to debate the current concepts and methods related to the food system. The first step addressed is a rigorous knowledge synthesis of sources focused on the food problem and the urgent necessity to change our nutritional habits. Finding, evaluating, and synthesizing led in to collect data and information about the current status quo of the food system (Section 3.1), opening the field to questioning how we can improve it reducing our environmental impact (Section 3.2).

The **Brettenzone**, a rather unknown strip of land in the west of Amsterdam, will be analyzed as a case study (Section 3.3) to elevate the public discussion about how reforming the food system bringing back to the city experiences of farming, local production and consumption and finally waste reuse. To do that, the **FEWprint** will be used as a parametric tool able to propose scenarios starting from shifting diet patterns and introducing new types of local production. The practices proposed aim to protect and improve both the health of the local communities and their environmental footprint, setting an encouraging vision in which local food management can play a central role in designing a fairer and more sustainable world.

IV. RESULTS

4.1. The environmental footprint of food

Agriculture is a worldwide network involving farmers and producers from all the different areas operating to provide about four billion tonnes of food each year (Ellen MacArthur Foundation, 2019). To reach this number of edible products, large quantities of resources are involved, often called inputs of agriculture. Many of these inputs are from finite sources, and in many cases, food production is in competition with other human endeavours for their use. Within this context, designing a circular local food system means not only prevent food waste but also save precious resources including land, water, and energy.

In this section, both the FEWprint tool and the data collected from a deep literature review (Appendix A) are used to calculate the environmental footprint of food in terms of land accounting, virtual water and carbon emissions. This schematic comparison gives an overall scope on the influence the different food typologies has in terms of use of natural resources, providing factual knowledge about product-specific environmental footprints that is often lacking among consumers.

4.1.1. Land accounting

In order to ensure the required annual quantity of food, a lot of the global Gha is devoted to food production. Global food production currently utilizes approximately 4.9 Gha of the 14.8 Gha of land surface area on the planet, though only about 10 Gha of the latter is capable of supporting productive biomass (not desert, tundra, mountains, etc.) for agriculture (Powell & Lenton, 2012). Although the numbers might suggest that there is plenty of room for the development of an extensive food system, it is important to point out that the number of unused lands is essential to maintain and protect the natural ecosystems the other species are relying on. Moreover, the land available for food production is decreasing due to different factors such as the way of growing crops stressing productivity before quality, often ending with soil degradation, and climate change, altering the traditional ecosystem of the different food products. Another factor to be considered is the competition with other land-use demands such as the urban sprawl and intensification of the global level of large-scale urbanizations, transport infrastructures, industrial complexes and leisure needs (Powell & Lenton, 2012).

In the last decades, the crescent demand for food resulting from a growth of population and increase of food waste, often resulted in increasing yield rather than expand farmed land, ted to the implementation of improved cultivars, engineering and field practices. On the other hand, a generic level of prosperity experimented especially in the more developed nations, resulted into a dietary shift from a more cereal-based nutrition to a trend of animal products (EAT-Lancet Commission, 2019), with serious consequences on the relative land accounting.

Figure 5. Land-use required for the production of different food types in m^2/kg.

From the analyzed data, is clear how crop-based food is less land-consuming than products derived from livestock, dairies and fish. Moreover, animal-based agriculture needs a considerably vaster amount of space to output the equivalent energy value: for example, while one hectare of land is needed to produce sufficient rice or potatoes to feed 19 to 22 people per year, the same area would produce enough lamb or beef to supply only one or two people (IME, 2015). The consumption pattern of specific foods can change rapidly over time, causing shifts in the total land accounting for food.

Nowadays, out of 4.9 Gha involved in agriculture, around 78% is used for livestock production (IME, 2015). In the coming years, new challenges are coming in terms of land use due to the growth of the world population. An increase in numbers of people to feed is going parallel to the current trend of extensive urbanism, pressuring the food system and making it inadequate to face the coming changes. Those factors become especially relevant in the Netherlands and the Randstad, defined by Gallego the densest area in Europe (Gallego, 2010), where the Global Footprint Network is denouncing the shortage of land available for agriculture within the country.

4.1.2. Virtual Water

All branches of agriculture rely on a supply of water in order to grown, harvest, and process food. Among the total amount of freshwater withdrawn for human use, 70% goes into agriculture (IME, 2016). Within the Dutch context, the government decided to face the decrease of fresh water available connected with the climate change developing a *Nationaal Waterplan* in which a low priority of fresh water is given to the agricultural sector (Ministry of Infrastructure and the Environment & Ministry of Economic Affairs National, 2015), pointing out the urgent reconsideration of this resource.

A consistent amount of water is devoted to grown food, but also for processing it. *Virtual water* is the term used to describe the water embedded into a product, from the beginning to the end of its process. Following the growing trend of population and the consequently the increasing food demand, sticking to the current diets in 2050 globally will be needed between 10 and 13.5 trillion of m^3 of water per year, about triple what is currently abstracted in total for human use (de Fraiture et al., 2007).

Figure 6. Virtual water required for different food types in l/kg.

How much water do we *eat* every day without realizing it? As shown in Figure 6, all food we eat needs a certain amount of water to be produced. The studies about water consumption of food products underline how goods derived from crops are significantly less water-demanding than the ones derived from livestock.

Another important factor when analysing the demand of water relative to the different food products is that they do not provide the same amount of kcal. For every cubic meter of water applied in cultivation, the potato produces 5.60kcal of dietary energy, compared to 3.86kcal calories in maize, 2.3kcal in wheat and just 2kcal in rice. For the same cubic meter of water, the potato yields 150g of protein, double that of wheat and maize, and 540mg of calcium, double that of wheat and four times that of rice (FAO, 2009). Completely incomparable are the values harvested from meat, where we need between 2.000 and15.000 liters of water to produce 1 kg of product, record belonging to the beef. In overall terms, the energy content of food materials varies from approximately 2 kcal per cubic meter of water in the case of plant-based food and 0.25kcal per cubic meter for food derived from animals. (USGS, 2020). Improving our diet can save water, shifting from beef consumption to crop-related products.

4.1.3. Carbon Emission

As well as the majority of human activities, agriculture and farming requires energy. Energy is the main input for a lot of engineered steps making possible and more efficient the production of food, but it is also demanded in other subsystems of the food chain such as transportation, distribution, consumption and disposition. From studies analysing the complex food supply emerged that, including the processing and transportation phases, it takes an average input of 7 to 10 calories of energy to produce just one calorie of edible food (FAO, 2011). Moreover, the implied energy is often coming from non-renewable sources, increasing agriculture's environmental footprint and making the food sector one of the main actors responsible for the climate changing.

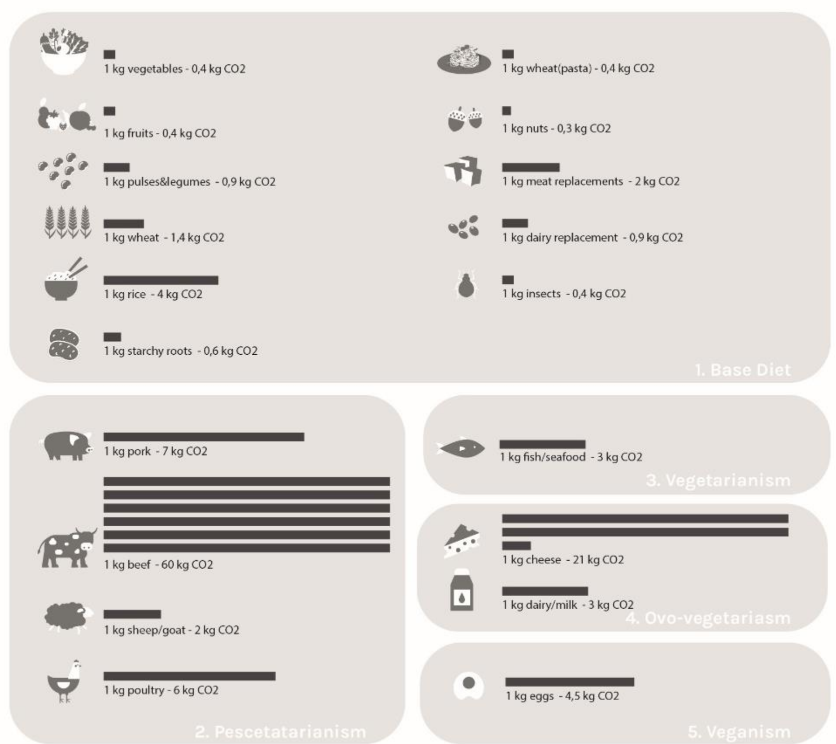

Figure 7. CO^2 emitted in the production different food types in kg CO^2/kg of food.

The overall 7 to10 calories average figure does not however reveal the differences between plant-based and meat-based foods, especially focusing on their carbon emissions. For example, less than 5 kg of CO2 is emitted while producing 1 kg of each element belonging to the base diet, while a peak of 60 kg of CO2 is registered in beef food manufacturing. This problem can be faced following the Ellen MacArthur Foundation approach toward the circular economy (Figure 8) based on three principles:

design out waste and pollution, keep products and materials in use, and regenerate natural systems (Ellen MacArthur Foundation, 2019). However, as demonstrated by the data displayed in Figure 7, this systematic approach cannot work if we stick to highly energy-demanding food consumption patterns.

Figure 8. Principles of a circular economy. (Ellen MacArthur Foundation, 2019).

4.2. Diet Impact

The diet is defined as repeated arrangements and quantities of food consumption. When studying the diets of an observed population group we define food consumption patterns. Food consumption patterns depend on several factors such as personal preference, habit, availability, economy, convenience, social relations, ethnic heritage, religion, tradition, culture and nutritional requirements (Gerbens-Leenes & Moll, 2006).

Healthy diets should not only consider the caloric intake but also the environmental footprint the different food groups show. By raising awareness on the impact of our diets, this paper shows pathways toward sustainable food consumption.

In this section, thanks to the FEWprint tool, the impact of the is being addressed grouping the different food groups in different patterns: base diet (showing all the groups), pescetarianism (cutting pork, beef, sheep/goat and poultry), vegetarianism (cutting fish), ovo-vegetarianism (cutting cheese and dairy/milk) and veganism (cutting eggs). Imposing those dietary changes by introducing substitutional food components (Appendix A, Table 2) in the urban context of the residential neighbourhood Buurt 10 within the Brettenzone, Amsterdam, different scenarios will display a mitigation of the environmental impact.

4.2.1. Current scenario

According to the RIVM maps about food consumption, Dutch consumers eat on average 1 kilo of foods and drink 2 litres of beverages daily, divided into breakfast, lunch and dinner, and 4 in between moments (Geurts et al., 2017). Per person, they consume around 210 grams of starch-rich products, 245 grams of fruits and vegetables, 300 grams of dairies and eggs, and 60 grams of meat and fish daily (specific breakdown of per capita food consumption in The Netherlands displayed in Table 3).

This consumption pattern can be applied to Buurt 10, the Amsterdam case-study neighborhood belonging to the Brettenzone. Buurt 10 is a residential community hosting 2415 habitants with a size of average household of 2,6 cap/hh (CBE & ESRI Netherlands). Using the FEWprint to cross their diet with the data about land accounting, virtual water and carbon emission collected in section 4.1, we can be able to calculate their environmental footprint related to food consumption.

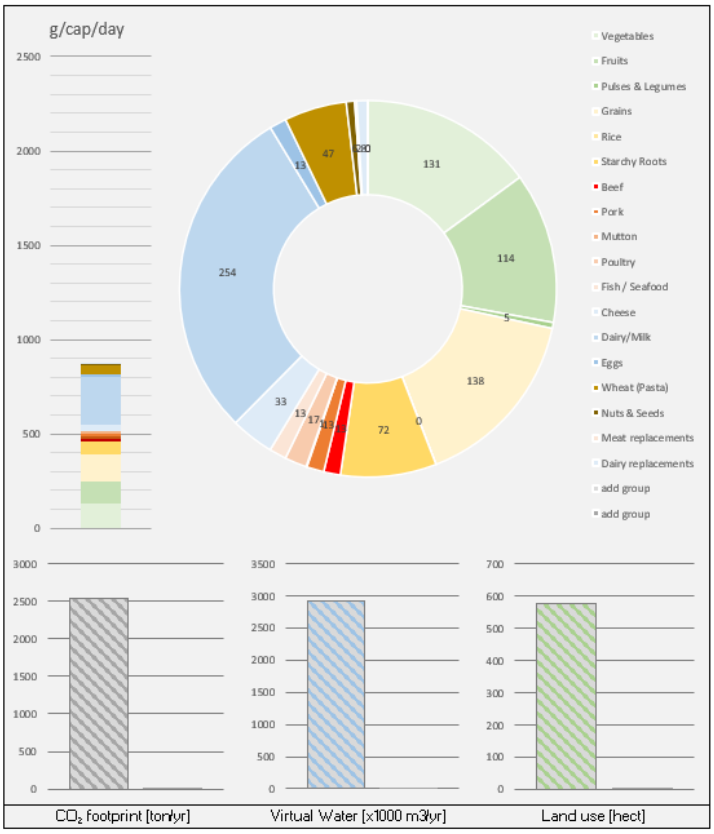

Figure 9. Buurt 10: food environmental footprint. Current situation.

Based on these food habits, the inhabitant of Buurt 10 are currently producing around 2.533 tons of CO2, withdraw 2.900 m3 of fresh water and using 580 hectares of land. Taking into account the case-study occupies an area of only 32 hectars (CBE & ESRI Netherlands), these data show the urgency to rethink our food habits, aiming for more sustainable scenarios.

4.2.2. Ideal scenario

The global population shifted from a cereal-and-plant-based diet to a more variegated one. During the last century, economic prosperity led to a variety in the food supply chain and globalization: food is shipped along long distances and we eat more processed food and less basic products. This tendency is accompanied with an increment of meat consumption and related huge repercussions on our environmental footprint.

To react to the food demand of a growing world population in a sustainable manner, global consumption of fruits, vegetables, nuts and legumes will have to double, and consumption of foods such as red meat and sugar will have to be reduced by more than 50%. A diet rich in plant-based foods and with fewer animal source foods confers both improved health and environmental benefits (EAT-Lancet Commission, 2019).

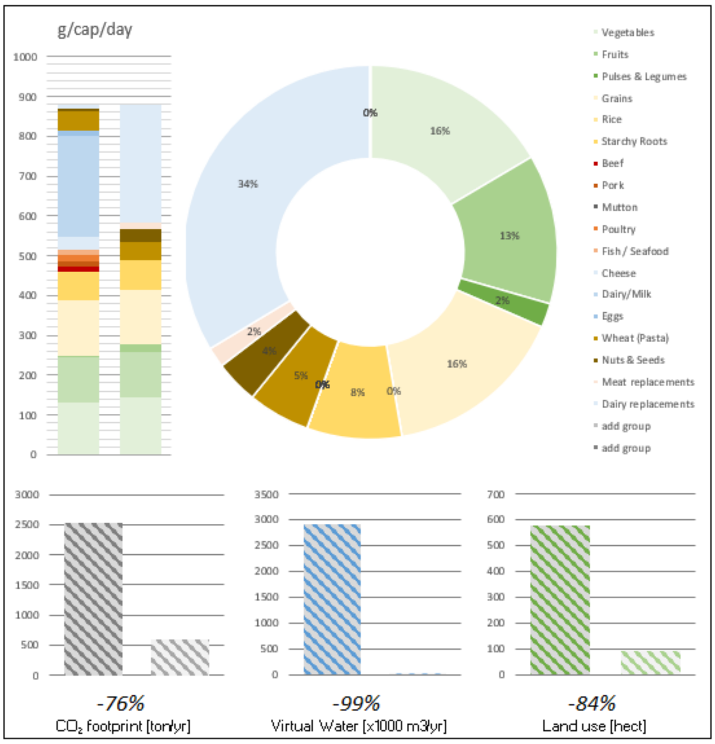

Figure 10. Buurt 10: food environmental footprint. 100% Veganism.

In the Netherlands, meat consumption has increased significantly from the fifties until the nineties, starting then to fell slightly, but remains much higher than it used to be in the past. Currently, more than a quarter of the food products and 10% of beverages has an animal-based origin (Geurts et al., 2017) and this is one of the focus of the current food problem.

A solution to this is to make significant diet shifts. Figure 10 displays an ideal scenario where 100% of the population within the analysed neighbourhood Buurt 10 would choose to follow a vegan diet, eliminating any form of animal-based product. This radical change in the consumption pattern shows to what extent an environmentally aware diet can reduce the food environmental footprint. More specifically, the CO2 emission would be reduced by 76% amounting to 249 kg/cap/year, the demand for water would be almost zeroed and the land use of the district would drop by 84% reaching 96,6 hectares against the 580 estimated for the current scenario.

4.2.3. Focus scenario

Despite the outstanding results displayed in the fully vegan scenario, encounter this response among the population is a utopic goal: currently, within the Netherlands, just 2% of the population is following a vegan diet (van Gelder, 2020). However, a more realistic improvement in diet habits could already contribute to reduce the impact of food consumption on the natural environment and reduce the use of input resources.

In the Netherlands, the topic of meat consumption is largely debated nowadays, convincing more and more Dutch to exclude meat components from their diet. Whereas in 2017 only just 6% of the surveyed people by Statista considered themselves vegetarian, by 2019 this percentage already doubled reaching 12% (van Gelder, 2020). Similar trends are reporting people who are simply reducing their meat consumption.

The vegetarian diet is in particular attracting young people in the Netherlands. In 2018, the amount of people not eating meat belonging to the 18-to-24-year-old group was five times the amount of over 55 ones (van Gelder, 2020). Are also the young people, in general under 34, the more responsive to a general reduction of the meat consumption.

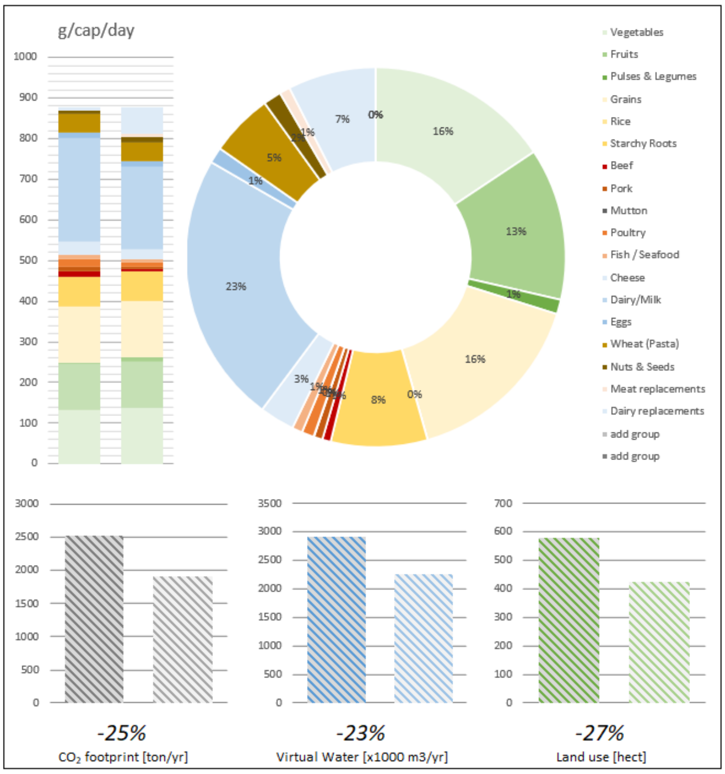

Figure 9. Buurt 11: food environmental footprint. Focus scenario.

Based on the previously mentioned trends a new and more realistic focus scenario can be created pushing forward the actual trend of reducing meat and other high resource-demanding edible products, with resulting consumption pattern similar to the one displayed in Figure 11. Following the diet hierarchy - since each broader restriction contains the stricter one - the dietary changes within the analysed neighbourhood were applied as follow: 50% of the population removing red meat (pesce-pollotarianism), 45% is removing meat (pescetarianism), 40% of the population follows a vegetarian diet, 20% of the people is removing also dairy (ovo-vegetarianism) and 6% of them is vegan. These shifts are particularly relying on the younger inhabitants: 29% of the people living in Buurt 10 are under 25 and 56% are under 45 years old (CBE & ESRI Netherlands), constituting the slice of population which will most likely change their consumption pattern. As displayed in the graph (Figure 11), these dietary changes lead to reduce of a quarter of the food environmental footprint, displaying 1.907 tons of CO2, 2.250 m3 of fresh water and a usage of 434 hectares of land.

4.3. Local food systems

The design of local food systems encouraging more sustainable diets can be seen as a bottom-top strategy to achieve an improvement and a shift in consumption patterns. Following the general aim to reduce the environmental footprint of local communities in terms of water, energy and land derived from their nutritional habits, new policies and practices related to food production and consumption have to be promoted. Within the contextual framework, these interventions strive to protect and improve the health and the surrounding environment of local contexts, enhance resilient livelihoods and communities and promote good stewardship of natural resources.

In the coming years, the role of food production within urban areas may become more important, cutting the incredible number of resources concerning the transportation step of the food supply chain. Even if satisfying the entire food demand harvesting within the cities borders is unrealistic, local systems can start involving more citizens in food-related procedures and raising awareness about the environmental repercussions of their diet habits.

Although is not clear whether these efforts will ever be able to provide a meaningful contribution to the total food demand of cities, there are already successful precedent examples. In Havana, half of all the fruit and vegetables consumed in the city is grown within the city limits (Brown & Carter, 2003), while in Brussels and Sao Paolo regenerative farming practices are being implemented to fulfill the internal demand of fresh products (Ellen MacArthur Foundation, 2019). This shows that within wider food and agriculture systems, localized urban food systems can play an essential role. If on one side is unrealistic to produce all the food within cities, bring back experiences of farming, local production and consumption and finally waste reuse could present a resilient and futureproof masterplan for urban scenarios. Since moving towards a circular economy for food is essential to face the growth of population, starting from involving citizens at a neighborhood level can be seen as the starting point for such a transition.

4.3.1. Current situation

Nowadays, a global network of mostly unknown suppliers and supermarkets chains provide the food to four million of people (Norman, 2012). People, especially citizens, are more and more disconnected from the food production and they eat more processed food than simple nutritional elements (Diet Collaborators GBD, 2019). This system affects the quality, the taste and the choice of our food, but also our daily surroundings.

Some generations ago, in the Netherlands was still full of people who have been born on farm, or were in daily contact with market gardens or nearby to one. The origin of their food was clear, close, controlled: cows were in the pasture and the landscape was mostly made out of water and fields that were harvested following the natural cycle of seasons. Instead, nowadays for both people living in cities and in the countryside, food is something produced and cooked in some far laboratories, prepared in mega-kettles from a mega-company, squeezed into a jar with a label bearing unintelligible information (just because it is demanded by law) and displayed in supermarkets. Costumers stands at the end of the consumption line, totally unaware of the procedures applied to provide their food, as well as of the repercussion their choices are having on the use of natural resources and they have totally forgotten food from traditional methods and natural processing such as fermentation to produce bread and cheese, the tinning of vegetables, and smoking of meats, which have been a part of people's dietary habits for centuries, and contribute to the availability of safer, more affordable and healthier diets than the one they have adapted now. (Pinho et al., 2020).

Currently in the Netherlands, about 66% of the household food budget is spent at supermarkets (Geurts et al., 2017). Determinants of food choices are variegating, going from prize convenience to personal background. Guide consumers in their consumption patterns, moving towards sustainable habits, have to start from designing a physical environment where healthy diets - not only in terms of nutrients but also regarding repercussions on the natural ecosystem - are encouraged.

4.3.3. Focus scenario

Following the bottom-top approach towards the design of a more sustainable food system, the discussion should focus on finding methodologies to enhance better lifestyles and less resource-demanding consumption patterns conducted by the inhabitants. This scenario can be possible providing local systems where natural products are largely available, and consumers are aware of the environmental repercussion they can have by making specific choices when they shop, or even by co-investing in innovative farm business.

Studies have shown that higher perceived availability of fruits and vegetables in the residential neighborhood was associated with lower consumption of ultra-processed and high resources-demanding food (Vedovato et al., 2015). Local food products can have an added value due to their narrative that matches what consumers are looking for, and being distinctive from the globalized and overprocessed products. Consumers themselves could become ambassadors of products if they feel invested in their choices (Boersma et al., 2019).

Cites - the place where 80% of food will be consumed in 2050 (Ellen MacArthur Foundation, 2019) - should invest in policies and spatial planning that include food production within their border, engaging more their inhabitants by reconnecting them to natural landscapes. The goal is to create a reliable and participative group of consumers, by integrate them into production practices. Citizens can play an essential role in food, choosing where they shop and what they buy. Providing them with sustainable options, while raising the awareness about food environmental footprint, can trace the path towards a more resilient food system.

Within Amsterdam, the Brettenzone displays as the perfect showcase for such a strategy. The area (also used for data collection in section 4.2), was already demanded for agriculture since the year 1000, when the main purpose of the exploitation of the peat zone was to create dry and usable arable land. Nowadays, it displays of a collection of half-executed plans, a rich but undiscovered cultural landscape. The design of a food strategy could then be the fixing element responsible to mend the fragmented urban fabric, encourage more sustainable consumption patterns by engaging the surroundings communities and enriching the natural park at the same time. This goal can be achieved by inserting food markets in connection with edible forests, combinations of allotments and common gardens based on permaculture experiences where people can learn for the first time, or again, how nature works. Following this intent, Figure 12 is displaying a green masterplan for the area that, starting from the analysis of the existing landscape, proposes a zooning pattern where more wild areas gradually flow into zones needing more maintenance describing green gradients. The result is a more resilient method of agricultural production, working with nature rather than degrading it.

While the current farming system in the Netherlands is far from being sustainable, stressing production to the disadvantage of nature and ecology, urban green spaces can be the experimental lab for a more resilient agriculture production, that enhance nature rather than degrade it.

Figure 12. Proposed reconversion of the Brettenzone into a local food park. Image by the author.

V. DISCUSSION

While the population is growing and the environment has lost its balance, an action is needed soon. Without a quick response and change of attitude, starting with our nutritional habits, we risk to fail our global goals UN established for Sustainable Development (SDGs: Sustainable Development Goals) (United Nations, 2015) and the Paris Agreement against climate change. Antonio Manuel de Oliveira Guterres, UN general secretary since 2017, pointed out how the food can play a pivotal role in reaching our goals for 2030, each of which relies to some degree on healthier, more sustainable and equitable food systems (United Nations, 2020).

This research builds a bottom-top approach to reduce the environmental impact of food systems. In order to do this, the food system has been divided into two subsystems: the production subsystems and the consumption subsystem. On one side, the production subsystem is being analyzed ion the results section in terms of land, water, and energy demands of goods. On the other hand, the study of a sustainable diet have been persuaded in order to present a more sustainable pattern for the current linear food system. Finally, in the section 4.3, solutions leading to the design of local food systems are presented as starting strategies to solve the problem presented.

One of the biggest dilemmas of this investigation was tackling such a broad without the help of other professions such as sociologists, economists, food entrepreneurs, city planners. The collaboration of the architect with other specialists is something every day more important: only by creating discussion tables with different actors, those kinds of community projects proposed in this paper as a solution to the food problem can turn into reality. Anyways this research wants to promote social interaction and guides towards a more community-based development that produces food more sustainably while leaving some open questions.

Can a grassroots, biodynamic and local food system be integrated in the city planning? Is it possible to change people's behavior towards more sustainable consumption patterns by proposing socially engages projects? The challenge is to strike intervention between the small scale and the globalized one, discovering the shadows in between. This can be the opportunity to link city dwellers and their food sources, shortening the chain by closing local cycles. At the same time, those interventions will enhance food security and improve self-resistance of urban communities. By proposing local food systems, food can become an interesting scope to look at cities, how they behave and which social themes they are facing.

VI. CONCLUSIONS

The way we produce and consume food poses big challenges for the years to come. While the population is growing, agriculture is one of the human endeavors having the major impact on the environment, underlining the urgency of rethinking our food strategy.

Lots of resources are nowadays required for food production. Those elements, often called input of agriculture, form part of our environmental footprint. In particular, a lot of water and land is used to provide each year the required quantity of edible product, while a lot of CO2 is emitted. The diets that have been adopted over the years play a significant role in these emissions hence also in their reduction, since not all the food components have the same environmental footprint. Especially the reduction of meat consumption is essential as all the peaks related to virtual water, land accounting and carbon emission belong to animal-related products. On the other hand, fruits and vegetables are the less demanding in terms of natural resources. Moreover, those food groups can provide more calories and energy in relation to their weight.

Therefore, healthy diets should not only consider the caloric intake but also the environmental footprint the different food groups show. Thanks to the analyses made with the FEWprint, is been proved that with a vegan diet - that totally avoid animal-related products - displays a reduction of 76% in terms of CO2 emission, a drop by 84% of land required and almost zeroed the necessity of water in comparison with the global average diet.

Given the impact people have on the planet in relation with their consumption patterns, awareness on the connection between diets and environmental footprint should be raised among common people. In particular, cities inhabitants should be more involved into urban policies that focuses on food, since it is estimated that 80% of food will be consumed in cities in 2050 (Ellen MacArthur Foundation, 2019).

This paper proses a bottom-top approach to the food problem, pointing out the necessity of involve cities in agriculture-related activities. Bringing food practices back to urban environments can raise the awareness about food impact both our life and on the surroundings, creating healthy, green, livable and sustainable cities.

Within Amsterdam, the a rather unknown strip of land called Brettenzone figures as the prefect scenario to showcase this approach. The area, already demanded for agriculture since the 11^{th} century, is displaying today as a wild landscape collecting unfinished plans to bring back farming to the city. The municipality, together with the inhabitants, already questions possible uses of the area, pointing out the necessity of really putting the Bretten on the map for Amsterdam's inhabitants by inserting recreational functions (LaBGreen De Bretten, 2020). A food-related program could be then proposed as the fil rouge linking the landscape to the development of more sustainable diets withing the surrounding communities.

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APPENDIX A

6.1. Food data

Table 1. World average: land use, virtual water, carbon emission.

Food Group	**Land use [m2/kg food]**	**Virtual water [L/kg food]**	**Carbon emission [kg CO2/kg food]**
Vegetables	0,3	15	0,4
Fruits	0,6	15	0,4
Pulses & Legumes	7,3	15	0,9
Wheat & Rye	1,4	20	1,4
Rice	0,8	20	4,0
Starchy Roots	1,2	20	0,6
Beef	164,0	15000	60,0
Pork	11,0	8000	7,0
Sheep/Goat	2,0	5000	2,0
Poultry	7,1	2000	6,0
Fish / Seafood	3,7	1000	3,0
Cheese	41,0	12000	21,0
Dairy/Milk	8,9	10000	3,0
Eggs	5,7	1800	4,5
Wheat (Pasta)	0,7	25	0,4
Nuts	7,9	25	0,3
Meat replacements	2,2	25	2,0
Dairy replacements	0,7	25	0,9
Insects	0,0	10	4,0

Table 2. Substitutional food components.

	(1) PPT	(2) PT	(3) VT	(4) OV	(5) V
	Replace **Red meat** with:	Replace **Poultry** with:	Replace **Fish** with:	Replace **Dairy** with:	Replace **Eggs** with:
Food Group					
Vegetables	25%	25%	25%	0%	0%
Fruits	0%	0%	0%	0%	0%
Pulses & Legumes	25%	25%	25%	0%	0%
Grains	0%	0%	0%	0%	0%
Rice	0%	0%	0%	0%	0%
Starchy Roots	0%	0%	0%	0%	0%

Beef	removed				
Pork	removed				
Mutton	removed				
Poultry	0%	removed			
Fish / Seafood	0%	0%	removed		
Cheese	0%	0%	0%	removed	
Dairy/Milk	0%	0%	0%	removed	
Eggs	0%	0%	0%	0%	removed
Wheat (Pasta)	0%	0%	0%	0%	0%
Nuts & Seeds	25%	25%	25%	0%	100%
Meat replacements	25%	25%	25%	0%	0%
Dairy replacements	0%	0%	0%	100%	0%
add group	0%	0%	0%	0%	0%
add group	0%	0%	0%	0%	0%
	Total	Total	Total	Total	Total
	100%	**100%**	**100%**	**100%**	**100%**

Table 3. Per capita food consumption in The Netherlands (RIVM).

Food Group	**[g/cap/day]**
Vegetables	131
Fruits	113,8
Pulses & Legumes	4,5
Wheat & Rye	138,3
Rice	0
Starchy Roots	72,2
Beef	12,6
Pork	13
Sheep/Goat	0,6
Poultry	16,6
Fish / Seafood	12,9
Cheese	32,6
Dairy/Milk	254,3
Eggs	12,7
Wheat (Pasta)	47,1
Nuts	6,3
Meat replacements	1,5
Dairy replacements	8,4